3D RENDERING DEPTH OF FIELD

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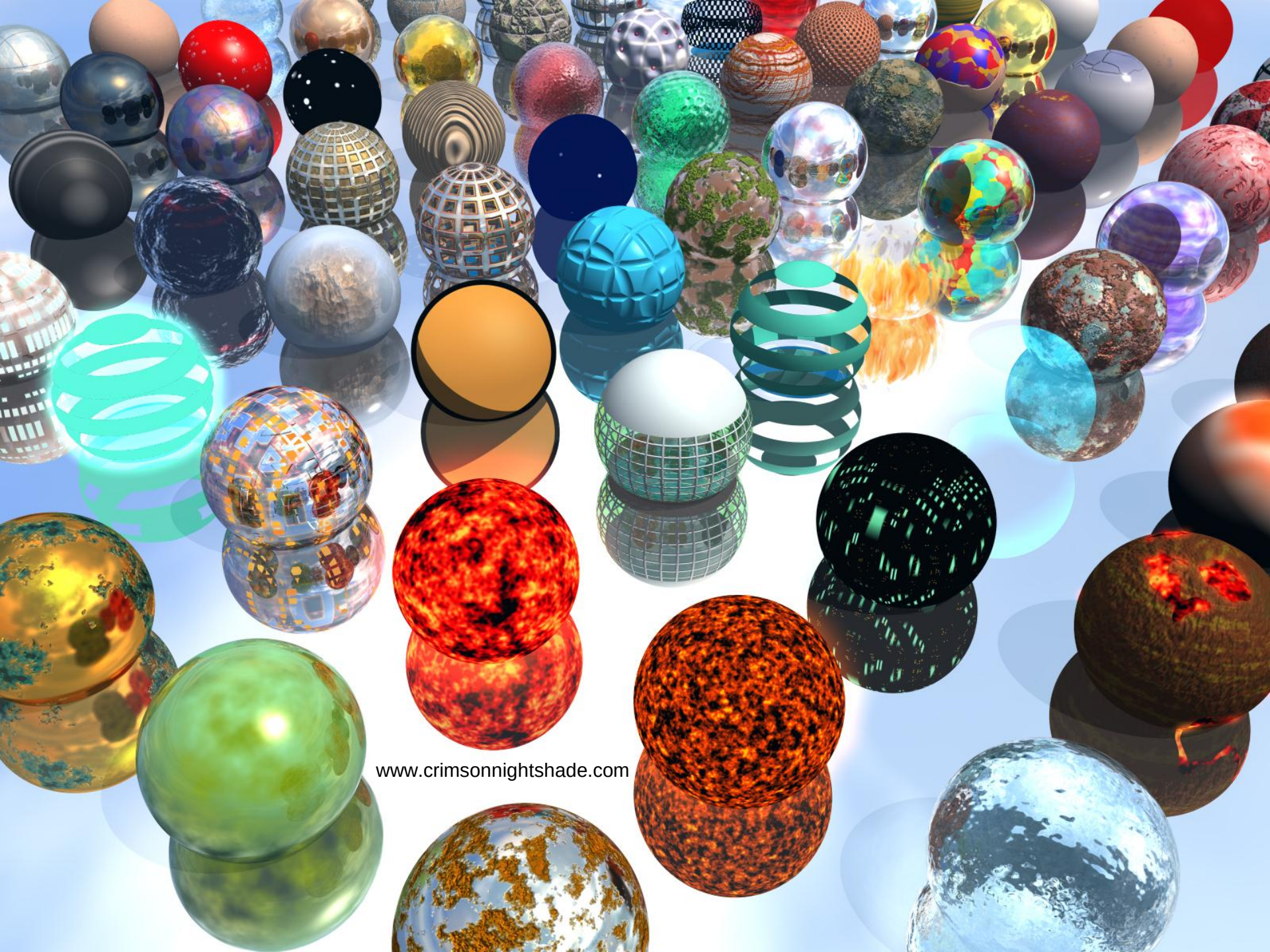
www.crimsonnightshade.com

Problem

- 3D rendered images are “too good”
- Everything is in focus
- Real world photographs have a limited DOF
- DOF provides artistic influence to the image
- DOF guides the viewer to the subject.
- WHAT is this next image?
  - Rendering or photograph?
  - … of what?


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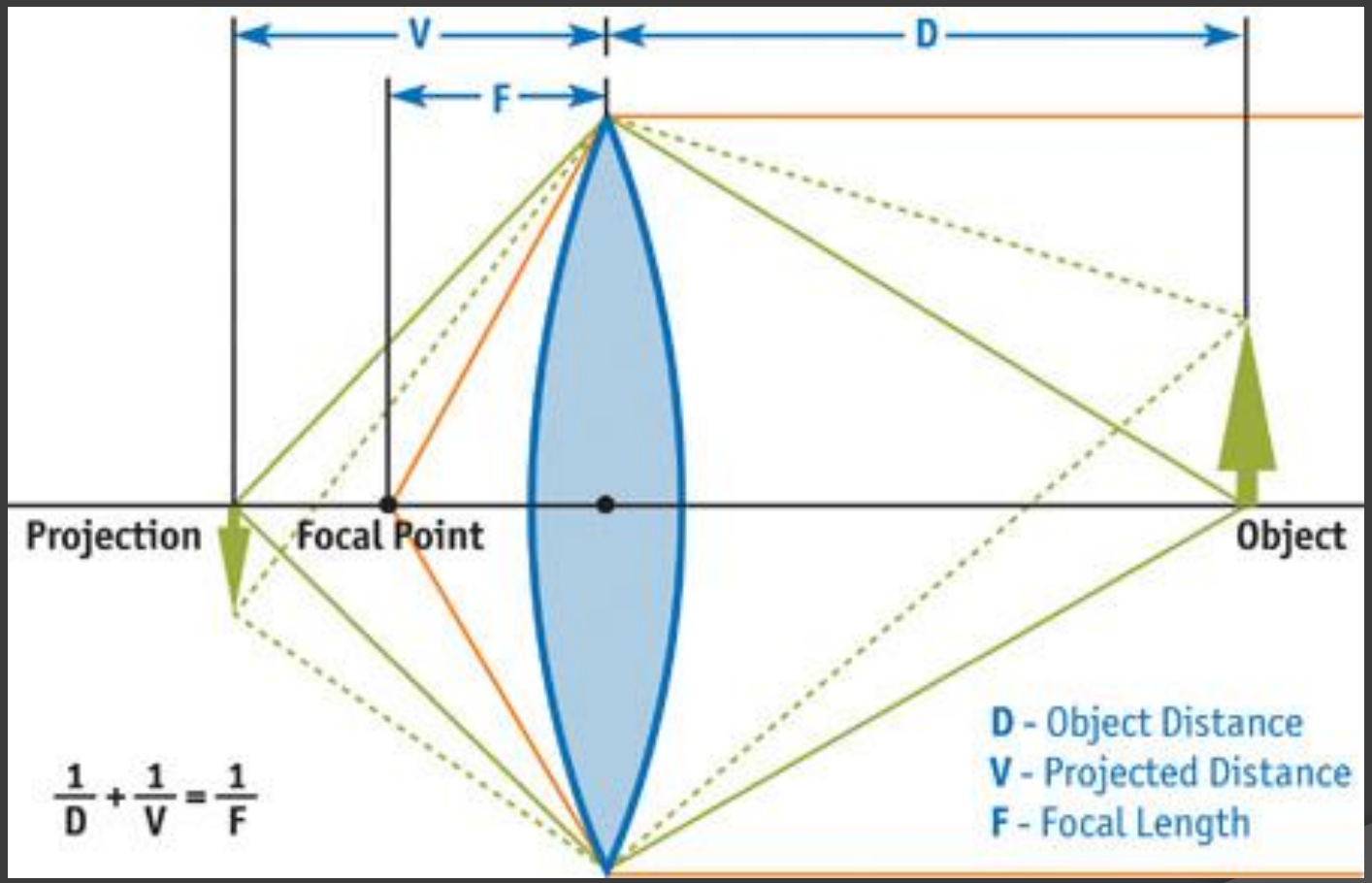
Wikipedia

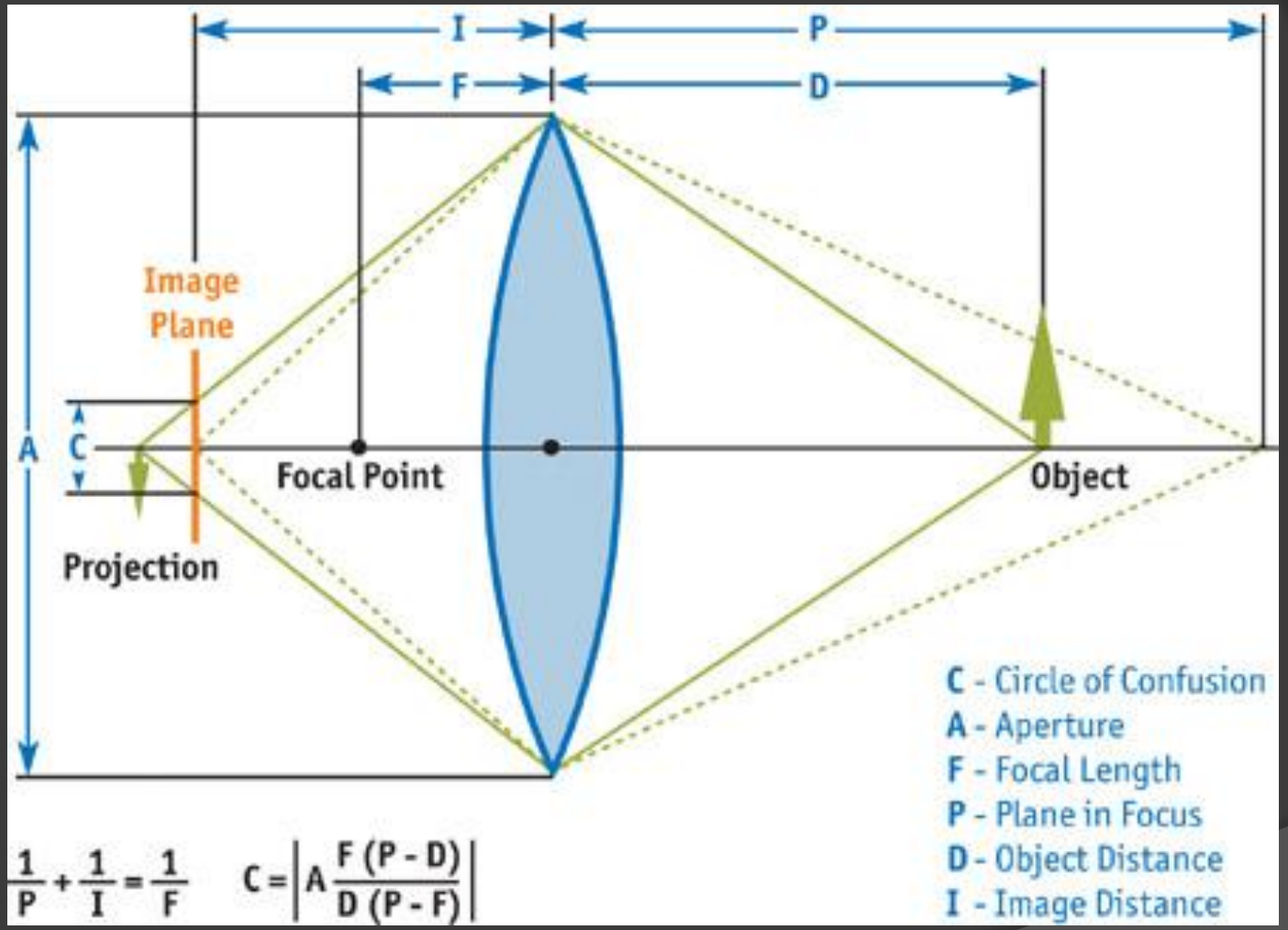

http://www.povray.org/hof/

DOF in photography

- Critical Plane of Focus (CPF)
  - Distance to the focal plane
  - Flat plane misnomer, the ‘plane’ is curved
  - DOF is a distance range, a volume of space
- Understand the Circle of Confusion (COC)
  - The area on the film plane where rays of light from one point collect
  - The bigger the COC, the ‘blurrier’ the image.
  - Sharp focus means the COC is smaller than…?
  - COC is a function of the aperture size and the distance to the subject / object



CPU Gems: http://http.developer.nvidia.com/GPUGems/gpugems_ch23.html



CPU Gems: http://http.developer.nvidia.com/GPUGems/gpugems_ch23.html

http://www.lightweaversphoto.com/fine_art/our_process.html

DOF in image rendering

- Blur the pixel as a function of it's depth
  - Depth map
- 3 algorithms required to create DOF
  - Determining Depth to intersection
  - Determining the COC
  - Blur the pixel
    - Accumulation buffer
    - Down sample blur
    - Multiple lens perspectives

Accumulation buffer

- Create sharp image
- Alter each pixel by averaging it with surrounding pixels.
- Fast – post render process

Down Sample Blur

- Create a sharp image
- Create a blurry image
  - Down sample
  - Gaussian matrix blur
- Faster - post render process
- Used in real time rendering (games)
  - pre-rendered blur map

Multiple Lens Perspectives

- Determine COC as function of depth to the subject
- Cast multiple perspective rays for a single pixel.
- Realistic effect requires lots of samples
- Slow

Solution

Down Sample Blur with Post-Render Averaging

- Render scene as normal
- Create a copy of the image and reduce size
- Perform 3x3 Gaussian blur on the copy
- For each pixel in the original image:
  - Determine the distance from camera (depth map)
  - Determine the distance from the CPOF
  - Calculate the final color as a mix of the original image and the blurred image

Implementation Strategy

- Changes to the GUI:
  - Select the Critical Plane of Focus (CPOF)
  - Select the amount to reduce the blurred image (2, 4, 8, 16)
  - “Depth of Field” button
- When “Depth of Field” button is pressed:
  - Create a copy of mResultImage called mBlurImage with reduced size.
  - Perform a Gaussian Blur on mBlurImage.
  - For each pixel in mBlurImage calculate the distance from the CPOF using the value stored in mResultPixelDepth.
  - Calculate the color of the pixel to set in mResultImage as a mix of mSharpImage and mBlurImage.
  - Update the display.

Implementation Strategy

- Gaussian Blur:
  - Create a copy of the original image (mOriginalImage)
  - Re-calculate the color for each pixel by gathering light from the adjacent pixels using the matrix shown below.

Gaussian Blur			
1	2	1	
2	4	2	
1	2	1	/16+0

Matrix for Gaussian Blur taken from:
http://www.codeproject.com/KB/GDI-plus/csharpfilters.aspx

Risk evaluation

- Algorithm performance – unreasonable time to render?
- Short development time frame (Due March 15th, 2010)
- Time to implement multiple DOF algorithms
- Keeping changes in sync – source control
- Potential Multithreading issues
- Moving bar for correctness - What looks best can vary from one person to the next

References

- Wikipedia: http://en.wikipedia.org/wiki/Depth_of_field
- Fernando, Randimi. 2004 “GPU Gems” http://http.developer.nvidia.com/GPUGems/gpugems_ch23.html
- Fernando, Randimi. 2008 “GPU Gems 3” http://http.developer.nvidia.com/GPUGems3/gpugems3_ch28.html
- Haeberli, Paul, and Kurt Akeley. 1990. "The Accumulation Buffer: Hardware Support for High-Quality Rendering." *Computer Graphics* 24(4). Available online at **http://graphics.stanford.edu/courses/cs248-02/haeberli-akeley-accumulation-buffer-sig90.pdf**